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The Logistics Constant Throughout the Ages

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War often conjures pictures of combat and large armies moving to the field inspired by a clash of political ideologies or ambitions. Indeed, the intriguing twists and nuances of the strong political current sweeping every conflict forward or the intricate strategy and battlefield tactics that vie for positional dominance can hold one's attention to the exclusion of all other aspects of war. Yet, the bulk of a commander's considerations involve the logistical limitations that drive changes to strategy and tactics in order to keep forces supplied and moving. All manner of logistical supplies are necessary to carry on military operations. However, fuel (fodder for animals or petroleum, oil, and lubricants [POL]) holds a special importance in that its supply has influenced and often dominated strategy as long as nations or states have fielded armies.

Transportation of supplies and materiel preceding modern day machines relied on some form of pack animal, principally horses. The horse's need for fodder dictated to the commander the terrain through which he could campaign as well as the campaign seasons.

Following World War I, new modes of warfare made the use of pack animals obsolete; however, armies still employed them on a much smaller scale to move supplies. Technology—manifested in aircraft and mechanized vehicles birthed in the First World War and nurtured during the interwar period—required a new type of fuel in the form of POL. During World War II, in the European Theater, massive armies raced across battlefields, and mechanized equipment greatly increased the spectrum of strategic possibilities. However, commanders still had to account for logistical considerations that would influence their tactics. Increasingly, POL dominated their strategy and tactics. Further, POL products accounted for the majority of supplies shipped into theater during the war.

Regardless of its modern connotation, POL's intrinsic equivalent throughout history has been fodder.

Military Campaigns, Strategy, and the Need for Fodder

Most great commanders in ancient times, such as Alexander the Great, attempted to limit the number of horses on the campaign by ordering the troops and their attendants to carry many of the own supplies.¹ Yet, historian Donald Engels notes that pack animals were still necessary to carry "... the army's noncomestible supplies, such as tents, hammocks, medical supplies, the ambulance, siege machinery, firewood, booty, and perhaps some of the women and children."² Though Alexander managed to significantly reduce the number of pack animals, Engels estimates that Alexander's army probably had about 6,000 cavalry horses and 1,300 baggage animals. Under the most favorable conditions, where the army campaigned in areas abundant in fodder and only needed to carry 1 day's supply of grain, they still needed approximately 1,100 pack animals to carry 269,000 pounds of grain, if each horse carried 250 pounds.³ Engels notes that if an army traveled through an area devoid of fodder the number of pack animals

needed to transport the grain and fodder requirements for 1 day would jump to 8,400 carrying approximately 1,260,000 pounds.⁴ Noted historian Martin van Creveld, in *Supplying War*, similarly describes a generic premechanized army in which "... the 40,000 animals accompanying an army would, therefore, require 800 acres per day."⁵ Horses were imperative in a campaign, yet their subsistence greatly strained an army's resources.

Prior to the 18th century, few improvements were made to ease the fodder supply problem in Europe. In fact, the French made the problem worse by bringing extra men on the campaign to forage for fodder in the army's immediate vicinity. Historian John A. Lynn estimates between "... 4,000 and 10,000 men [were] necessary to mow forage for an army of 60,000"—each day a horse required approximately 24 pounds of dry fodder.⁶ Interestingly, the French did maintain a magazine system to store troop provisions; however, the need to keep moving to find more fodder tended to cause the army to move too far and too fast away from this system of supply.⁷ The ever present need to forage for more fodder forced the French Army to constantly move even when strategy dictated that it should not.

Strategy had to be adapted to account for horses' needs. Most historians agree the challenge of providing for the pack animals overshadowed the troops' provisions. Accordingly, the fodder requirement restricted an army's area of operations to regions that could sustain a high fodder intake. During the winter months when cold weather made fodder impossible to secure, armies were unable to campaign, and military operations necessarily became a seasonal activity.⁸ Notably, in the 13th century, the Mongols possessed horses that could find food under the snow, so their timeframe for waging war was greatly increased.⁹ Early conquerors bypassed cities and only occasionally conducted sieges, as fodder in the immediate area quickly ran out.¹⁰ Intuitively, the massive effort required to forage dictated strict precautions to prevent being surprised while gathering fodder. Though other factors also influenced strategy, the need for fodder dominated both strategic planning and military operations.

Throughout the first millennium AD, the Muslims were adamant about incorporating knowledge of terrain and vegetation when planning raids. Muslim planners devised contingency plans dependent on the seasons in that, during February and early March, their raids only lasted 20 days so they could get the horses back to Muslim territory to graze. Spring campaigns could only last 30 days, while summer ones were to last 60 because of the availability of fodder.¹¹ However, the Muslims were also sufficiently organized to set up a series of warehouses near their eastern frontiers over which they campaigned. Reports of these warehouses came in the 7th century and again in the 10th century relating the existence of ready supplies, "... including grain and fodder ... [and] located where defensive or offensive action tended to repeat itself."¹² Despite the Muslim's successes, by the 18th century, few countries had adopted a suitable fodder magazine system except for the French

and Prussians.¹³ The French and Prussian magazine system, as well as the earlier Muslim warehouses, gave the respective forces the advantage of surprise and a greater measure of flexibility by allowing them to mobilize and attack more quickly.

As mentioned earlier, Alexander the Great grappled with the fodder problem throughout his farflung exploits across Europe. Alexander realized the problems posed by bringing along numerous horses and pack animals, so he attempted to minimize their numbers by requiring his men to carry packs.¹⁴ He also understood that excessive work and not enough food would wear out his cavalry and pack animals and he would not be able to nurse them back to health.¹⁵ Welfare for the horses dictated that he slow his army's pace so the horses and pack animals could graze. The need to move faster, therefore, motivated Alexander to look for new ways to reduce his dependency on horses. His massive fleet helped alleviate this problem by transporting large fodder supplies from port to port, though this locked him into a dependency on the Mediterranean coastline or large navigable rivers, especially during winter.¹⁶ The need to provide fodder for his horses forced Alexander to work within increasingly narrow boundaries as he moved farther away from Macedonia. Alexander's campaigns provide one of the earliest recorded examples of logistical handicaps.

As long as armies required horses for cavalry and carrying supplies, the need to find fodder restricted flexibility and operations. In 1775, during the American Revolutionary War, American forces under General Philip Schuyler planned an invasion of Canada. However, lack of rain made for a hot, dry summer, and General Schuyler could not move up enough fodder to feed the horses needed for a full invasion. Instead, the lack of fodder forced him to wait until late summer when adequate rain nourished the grass enough to supply the invasions.¹⁷ Winter quickly set in after Schuyler experienced early successes and cut him off from all resupply. The "... inadequate forage in June and July was not the only reason for the failure of the Canadian campaign, but it surely was one of them."¹⁸

Fodder further affected flexibility during the American Revolution when free fodder became hard to obtain and the Colonial Army had to compensate farmers for using their land. Wartime prices steadily rose as good pastureland became less available. However, like Alexander, the American commanders understood that without adequate fodder their limited supply of horses would dwindle. Colonial commanders could send the cavalry away from the army to find cheaper fodder, but they needed the pack animals to stay close and often paid high prices for their nourishment.¹⁹ Without the pack animals, the army could not transport its supplies and conduct operations for very long.

The US Civil War (1861 to 1865) demonstrated the importance of using a rail system to increase strategic flexibility by more efficiently supplying armies. Trains and rail lines came under attack as both sides sought to cripple the other's access to them and prevent valuable supplies from reaching their intended forces. Armies still required cavalry and pack animals to move their food and supplies while in the field and, therefore, continued to need fodder. However, with the locomotive's introduction into warfare, fodder and other supplies could be loaded onto trains and brought to depots within the army's proximity. Established supply lines could then be used to retrieve the materiel. The Civil War became the first conflict in which armies used the new technological innovation to improve logistics, especially resupplying fodder, and to alleviate the need to constantly change camps to find more fodder.²⁰ In fact, historian James A. Huston, in *The Sinews of War: Army Logistics 1775-1953*, relates that shipments of forage during the winter months averaged \$1M. He

goes on to say that fodder continued to dominate supply considerations, in that "... for tonnage and bulk the item of daily supply that was even more important than food for the men was food for the animals."²¹ Trains permitted armies to receive more fodder while maintaining their positions and simultaneously allowed an army to keep more horses.

The period between the Civil War and World War I was filled with advances in technology, which were not fully taken advantage of by the European powers. Further, the dominant powers in Europe (France, Prussia, England, and Russia) failed to truly understand the lessons that could have been learned from the Civil War. Cavalry charges and long baggage trains of horse-drawn wagons persisted, and with that returned the age-old need to feed the livestock. In many ways, the First World War resembled all past wars. However, its rapid consumption of supplies, especially ammunition, dictated that the times and ways of war were changing. But for the moment, it was remarkably similar to the past, in that during the war, Great Britain shipped 5,253,538 tons of ammunition to France as well as the greatest single item shipped, which was 5,438,602 tons of oats and hay.²² Fuel for horses continued to be a dominant factor.

Regardless of the lessons the Germans should have learned from the past, during World War I, they placed a huge emphasis on cavalry and did not prepare for their maintenance in the field. The German high command ordered commanders to feed their horses off the land as a result of the army's sheer numbers of horses. Van Creveld relates that any attempt to supply the army from home bases would have been impossible.²³ As the Germans moved into France early in the war, luck appeared to be with them as the land was rich and the grain had just been harvested. However, much of the grain was still green, causing many of the horses to become sick and die very early in the campaign. A critical shortage resulted in fodder, and by the time of the Battle of the Marne, where French and British forces engaged and halted the German advance, most of the horses were too weak to keep up the pace.

The German invasion plan, known as the Schlieffen Plan, depended on the speed of the invasion, yet the horses employed in reconnaissance and pulling the heavy artillery were so poorly fed that they could not keep up the pace. In fact, many died before the Germans crossed the border into Belgium. By 11 August 1914, preceding the Battle of the Marne, cavalry forces ordered a 4-day halt to find food for the mounts.²⁴ By the Battle of the Marne, the starved horses pulling the German artillery, which was the only arm that had a distinct advantage over French forces, could not keep up the pace. "By this time, too, one German army at least was finding that the states of the cavalry seriously interfered with operations."²⁵ The German high command's severe oversight of properly feeding the horses proved to be a decisive factor in the failure of the Schlieffen Plan.

Following the offensive stall after the Battle of the Marne, the consumption of supplies reached proportions unmatched by any previous war. However, this consumption rate could not have been maintained if the front had not stalled and remained stationary throughout the war.²⁶ Supply movement via horses would have been inadequate given the war's immense scale. Toward the end of the war, both sides began to introduce motorized transport on a very small scale and began to argue that, "... complete motorization of local transportation and the widespread use of combat vehicles would restore mobility to the battlefield."²⁷ Petroleum products, then, came into demand, and by the war's end, more than 759,000 tons of gas and oil had been shipped onto the Continent. War planners deemed the horse obsolete in favor of the more economical and faster moving petroleum-based machines.

Military Campaigns, Strategy, and the Need for POL

Following the First World War, armies began nurturing the technological innovations employed at the end of the war and subsequently developed a strong dependency on petroleum products by the beginning of World War II. POL significantly differed from fodder in that POL had to be manufactured away from the battlefield and then shipped to the battle area.²⁸ For the most part, fodder as a source of fuel for horses quickly became a thing of the past as armies became fully mechanized. The new machines could be worked harder and go farther and faster, and most important, the time of the year and the route taken by the army did not affect its fuel supply. Commanders could expand their range of strategic operations immensely and do more with less.

However, challenges quickly attached themselves to the new machines and their fuel supply. If army quartermasters did not constantly provide the machines with enough fuel, operators could not normally just forage for it. In this respect, commanders lost a measure of flexibility, and the situation forced them to further employ technology to devise ways to overcome the new problems. The result involved underground pipelines and the Red Ball Express, in which a constant stream of trucks traveled distances of up to 400 miles to supply Patton's Third Army.

The beginning of World War II saw the Germany Army still reliant on horse-drawn transport. Hitler neglected to fully mechanize his transport vehicles, though he dramatically increased the number toward the end of the war.²⁹ Historian Julian Thompson relates that the Germans only possessed three motor transport regiments for the whole army capable of carrying 19,500 tons, whereas in 1944, the Allies in northwest Europe could transport 69,400 tons to support 47 divisions. Thompson goes on to state, "Hitler's failure to build up the necessary capacity to provide the transport essential for mobile warfare was one of the principal reasons for the failure of the German invasion of the Soviet Union (Operation Barbarossa)."³⁰ Regardless of the German Army's deficit in mechanized transport, the Second World War became the pioneering conflict to be predominantly affected by fuel in the form of POL.

Following Germany's invasions of Poland and France, POL's role became readily apparent, and Allied strategists sought to cripple the Axis' ability to effectively employ fuel with US entrance into the war. Plans got under way to target the Ploesti oilfields in Rumania as strategists estimated that the fields had the capacity to produce 9 million tons of refined oil per year, though it only produced 4 million. Allied strategists understood well the German's primitive transportation system and the fact their small fleet of motorized transport vehicles had become extremely overburdened by the war's rapid geographic expansion.³¹ Accordingly, the Allies did not attack Ploesti in the hopes of crippling the Axis refining capacity. Instead, they were more interested in destroying Ploesti's refining capability so Germany's limited transportation system would have to move the crude oil from the Ploesti area to other refining sites in Germany or France. The war had already severely taxed the Axis transportation system, and the Allies believed the extra strain would cause supply to other areas to fall apart.

The Allies launched the first Ploesti raid on 1 August 1943 and estimated that the Axis oil supply had been reduced by 3 or 4 percent.³² It was originally believed the raid had destroyed about 40 percent of 6 months of Rumanian refining capacity or a loss of 1.8 million tons of refining capacity as a result of closing the refining facilities from about 1 week to several months.³³ However, the raid's after action analysis indicated that Rumanian oilfields possessed twice their estimated production capacity, so subsequent raids would have had to destroy about 3 million more tons of refining capacity to begin really limiting

Ploesti's actual refining capacity.³⁴ Though the mission proved to be successful, the Army Air Forces sustained a 30 percent loss, making a follow-up raid impractical.³⁵ The Allies moved on to other targets, and the Germans managed to quickly rebuild the facilities.

Evolving into a strategy to attack the entire Axis oil industry, the raid, despite its heavy losses, fueled an intense bombing campaign that managed to strike every major oil refinery in German controlled territory. Ambitiously, the United States and Great Britain set out to severely damage the German oil industry and keep it subdued. Like Ploesti, the Allies' goal was to reduce the German refining capacity as well as the number of refineries available to cannibalize in order to rebuild larger, more productive refineries.³⁶ They wanted to present Germany with only two options: transport the crude oil to old unattacked refineries near Marseilles, France, where they were highly vulnerable, or stay in their present locations and attempt to rebuild in between raids.³⁷ The Germans chose the second option, and the Allies timed return missions to prevent refineries from going back on line.³⁸ As German oil production suffered, so did its armed forces as lack of aviation grade fuel kept the Luftwaffe on the ground and forced the army to heavily dip into rapidly dwindling reserves.

The Germans failed to completely think the entire war effort through and suffered from inadequate fuel reserves. The German Oil Association advised the government that the oil reserves would only last for 5 months given the high rate of consumption. Germany made the reserves last a lot longer by robbing from the civilian sector, but the effects of the Allied bombing after 1943 made the situation critical. Germany's aggressions in 1939 and 1940 were rewarded with its victims' oil reserves. A US investigation following the war relates, "... in January 1941 aviation gasoline stocks were approximately 500,000 tons. When Germany conquered the Netherlands, Belgium, and France, about 1 million tons were secured."³⁹ However, by January 1944, aviation gas had been reduced to 240,000 tons, and by January 1945, it was almost nonexistent.⁴⁰ By May 1944, fuel shortages resulted in drastic reduction in training hours, and operational time was limited strictly to air defenses.⁴¹ The situation had become so critical that the Luftwaffe could provide little opposition to the Allied invasion on 7 June 1944. By 1945, it could not support German ground forces in the Battle of the Bulge after a successful ground offensive.

Germany's lack of fuel reserves also manifested itself in ground operations as the combined bomber offensive and the Allied advance prevented German recuperation. Following victory in North Africa and a successful invasion of Sicily, the Allies drove up the Italian peninsula until stiff German opposition along the Gustav Line halted their advance. The Allies initiated Operation Strangle from 19 March to 10 May 1944 to cut the Germans off from resupply and deplete their fuel reserves. Generally successful, Strangle did not dislodge the Germans, and Operation Diadem got underway on 11 May 1944 to increase German fuel consumption while reducing their resupply through interdiction.⁴² Strategically, the Allies planned to dislodge the Germans while strategic bombing would prevent resupply in hopes they would run out of fuel.

Operation Diadem went according to plan, and by mid-May, 14 fuel depots had been critically depleted, and "... the mobility of the entire army had been called into question."⁴³ German fuel was adequate to compensate for the defensive maneuvers necessitated by the Allied advance at the beginning of the operation. Yet, by early June, the effects of the campaign presented a very hard reality. The German armies had been in retreat for a week, and the American Fifth Army presented a constant threat.⁴⁴ Though this defense suited the mountainous terrain and the situation, it required a lot of fuel that the army did not possess. "By June 6, the army

was making its moves piecemeal—a unit would move, exhaust its fuel, and wait for resupply.⁴⁵ Defensive maneuvers, the mountainous terrain, and movement at night saved the German Army from total defeat, but fuel's use in strategy and its subsequent effect on Germany strategy was enormous.

On 6 June 1944, the Allies launched Operation Overlord, and the invasion of Eastern Europe began. Original plans called for the Allies to steadily push the German Army toward the Rhine and then force surrender. However, after a massive aerial bombardment on 25 July, the Allies forced a gap in the German lines and then exploited it by pouring through armored divisions.⁴⁶ New tactical opportunities to quickly defeat the Germans presented themselves instead of the originally planned methodical push to the Rhine.⁴⁷ Patton's Third Army raced through southern France consuming an average of 350,000 gallons of fuel each day.⁴⁸ By 7 August, the Third Army had exhausted its fuel reserves, though it managed to maintain the rapid advance for another 3 weeks. Fuel supply reached critical levels from 20 to 26 August when both the First and Third Armies, pursuing the retreating German Army, consumed an average of more than 800,000 gallons of gas a day.⁴⁹ However, the supply lines had not yet become so long as to be unmanageable by theater logisticians, and the Allies had enough fuel to enter Paris on 24 August.


Pre-invasion planning called for the Allies to halt and wait for the logistical network of communications and food pipelines. However, their shipping successes and rapid advances into Paris with little German resistance called for a reevaluation of the plan. General Bradley, commanding the First Army, was quoted as saying, "... armies will go as far as practical and then wait until the supply system in [the] rear will permit further advance."⁵⁰ Basically, he proposed to move forward, taking as much ground as possible, until they ran out of gas. Once again, fuel requirements dominated strategic decisions and operational action.

Since World War II, POL has become increasingly important to keep an army going in the field. The past 50 years of technological advance have only optimized modes of transportation, not lessened the impact of fuel on strategy, tactics, and operations. While technological advances may reduce the amount of support equipment required for military operations and the size, lethality, or amount of munitions—all of which will further reduce lift requirements—similar advance is seen as unlikely for fuel. Arguably, fuel will remain the dominant logistics factor that limits strategic and tactical planning as well as actual operations for the foreseeable future.

Notes

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14. Engels, 129-130.
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29. Thompson, 53.
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31. Damage Report, Ploesti Area Oil Refineries, 31 August 1943, USAF Historical Research Agency, 142.042-21 V.5A.
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33. Ibid.
34. Ibid.
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42. Eduard Mark, *Aerial Interdiction: Air Power and the Land Battle in Three American Wars*, Washington DC: Center for Air Force History, 1994, 179.
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44. Ibid.
45. Mark, 207.
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49. Anders, 3.
50. Ibid.

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Although the United States is at present still in a class of its own economically and perhaps even militarily, it cannot avoid confronting the two great tests which challenge the longevity of every major power that occupies the "number one" position in world affairs: whether, in the military/strategical realm, it can preserve a reasonable balance between the nation's perceived defense requirements and the means it possesses to maintain those commitments; and whether, as an intimately related point, it can preserve the technological and economic bases of its power from relative erosion in the face of the ever-sifting patterns of global production.

—Paul Kennedy